Fish populations in planted and naturally colonized wetlands (fall 2005)

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Abstract

We examined the difference in the number of fish between two created wetlands, one that was planted and one left to colonize naturally. Minnow traps were used to sample the fish populations in the three basins located in each wetland. Green sunfish was the primary fish in the two created wetlands with a few other species present in low numbers. The population of green sunfish in the planted Wetland 1 (W1) was higher than that seen in the naturally colonized Wetland 2 (W2), likely because of the difference in plant species composition between the two wetlands. Significantly more green sunfish were caught per trap hour in W2 than in W1 ($p = 0.013$, $t = -2.73$). The difference in trapping success between the two wetlands was likely due to sampling bias. Seasonal changes in water level has a large effect on green sunfish population dynamics in the two wetlands as the population estimate for 2005 with constant water level was three to five times higher than 2003 or 2004 when the water levels were allowed to fluctuate. Common carp population saw a drastic increase during the second year of the water fluctuation study but no carp were detected in 2005 when water levels were kept constant. There were a total of six fish species captured in the two wetlands with four species being caught in each wetland

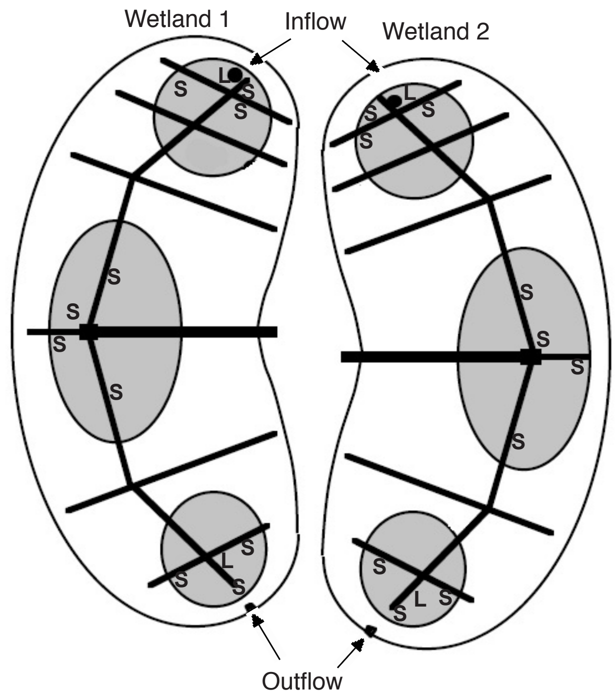

Figure 1. Map of the two created wetlands at the Olentangy Wetland Research Park with trap site locations. S = small trap opening and L= large trap opening.

Introduction

Wetlands are an important ecosystem that share characteristics with both terrestrial and aquatic ecosystems. Assimilation of excess nutrients in wetlands makes them an important part of today's environment. Wetlands serve as an important habitat for wildlife such as ducks, shore birds, piscivorous birds, certain mammals, frogs, salamanders, and fish. Many species depend on wetlands for at least some stage of their life cycle (Mitsch and Gosselink, 2000). Wildlife takes advantage of the assimilation of nutrients and the high primary productivity found in wetlands. The lush vegetation found in wetlands is used by many species for nesting, hiding spots, consumption and habitat.

The two 1-ha created freshwater marshes at the Olentangy River Wetland Research Park (ORWRP) serve as important habitat for many species and were set up as an experiment testing the colonization of species into created/disturbed wetlands. Wetland 1 (W1) was planted in 1994, while Wetland 2 (W2) was left to colonize naturally. The wetlands were built to mimic freshwater marshes in a riparian ecosystem (Gardner and Johnson, 1997). Each wetland was constructed with three sub basins, one at each section inflow, middle, and outflow (Figure 1). Water is currently brought into the wetland through a conventional pump, but in the past water was also brought in through a discflo™ pump, which allowed a greater number of organisms to enter the wetland from the river without the mortality caused by the impingement mechanism used in the conventional pump (Zuwerink, 1999). It is likely that most fish are unable to enter the wetland through the conventional pump, thus, inflow of fish primarily occurs during major flooding events (Zuwerink, 1999). During 2003 and 2004 the water level in the two wetlands was allowed to fluctuate and during 2005 the water level was kept constant. The effects of changes in water level are part of an ecosystem scale experiment being conducted at the Olentangy River wetlands from 2003–2005.

Freshwater marshes are highly productive as the low water levels and typically high nutrient loads encourage growth of submergent and emergent plant species and supports large populations of invertebrates (Mitsch and Gosselink, 2000). Freshwater marshes can be a harsh environment for aquatic species due to large temperature, turbidity and/or oxygen fluctuations caused by the low water level and exposed nature of freshwater marshes. For a fish species to survive in this productive habitat it must be able to cope with large fluctuations in the physical environment through behavioral or physiological adaptations.

Green sunfish (*Lepomis cyanellus Rafinesque*) is the primary fish species found in the two created wetlands (Custer et al., 2000; Smith and Mitsch, 2004). This species can tolerate a wide range of environmental conditions including extremes in turbidity, dissolved oxygen, temperature and alkalinity and are typically found in low order streams and ponds that do not support other sunfish (Trautman, 1981; Robinson and Buchanan, 1988). Green sunfish are found across the central and eastern United States and southern Canada and have been introduced into much of the southwestern United States (Meredith and Houston, 1988). Vegetated areas (submergent and emergent) are typical habitat for green sunfish (Meredith and Houston, 1988; Robinson and Buchanan, 1988), whose predatory nature may keep other populations of fish from establishing in these areas (Lohr and Fausch, 1996). Green sunfish are typically not present in high order streams, or are reduced in population size when large predator fish are present (Trautman, 1981; Robinson and Buchanan, 1988). Green sunfish will likely occur in most freshwater marshes as low water levels will not typically support large predatory species, and because of the ability of this sunfish to thrive under the extreme conditions found in this environment. Under ideal conditions green sunfish will grow to 200–250 mm in length, but under harsher conditions growth will be reduced (Trautman, 1981; Robinson and Buchanan, 1988).

This study was designed to calculate population densities and fish age structure in the two created wetlands. The goal of the study was to quantify the population of each species of fish in the wetlands and to determine if there was any difference in age/size structure between the two wetlands.

Methods

Data collection:

Data was collected in the two created wetlands using ten minnow traps per wetland that were 56 cm in circumference, 48 cm in length and had an 8±2 cm (small) wide opening and two minnow traps per wetland of the same dimensions except the opening was increased to 12±2 cm (large). The ten small minnow traps were placed at predetermined locations in each wetland (Cochran, 1998). The two large minnow traps were initially placed at the inflow, but after the second day one trap was moved to the outflow where more fish were being caught. The large minnow traps were used to catch larger fish for age determination. Traps were checked daily during the first seven days, after which the checking of traps was sporadic. All green sunfish captured were fin clipped and length and weight measurements were recorded. All other species were measured and weighed, but not fin clipped due to the low number of individuals present and low survival of released shiners (*Notemigonus* spp.). All fish were released in the same subbasin at least 1 m away from any trap. Scales were collected from five fish from each size class (5 mm increments) that were 55 mm or larger. The scales were collected in coinsized envelopes and labeled with information from each fish. Scales were then pressed onto plastic slides and the indentions were viewed using a microprojector and age was determined using concentric rings, which were classified into annuli.

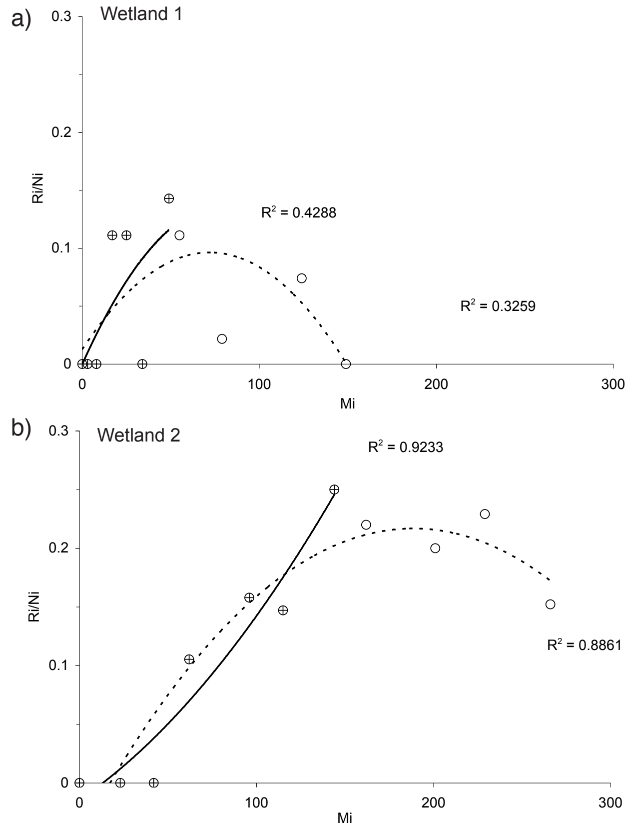

Figure 2. Comparison of data collected during the first 7 days of the study (+, with a solid trendline) and the full data set (o, with dotted trendline), for Wetland 1(a) and Wetland 2 (b). A straight line indicates that the data meets the assumptions of the Schnabel population equation.

Data analysis

The Schnabel population estimation formula was used to calculate the population of green sunfish in each wetland (Ricker, 1975).

$$N=\sum(CiMi)/\sum(Ri) \tag{1}$$

where:

Ci = total number of fish captured on a specified sampling

Table 1. Fish captured during sampling period at two created wetlands.

Species	Wetland 1	Wetland 2
Green sunfish	180	304
Bluegill	1	1
Common shiner	0	3
Largemouth bass	1	0
Smallmouth bass	1	0
Spotfin shiner	0	1

day i.

Mi = total number of fish marked and released back into the population prior to the sampling day.

Ri = total number of marked recaptures during sampling day.

Assumptions for this method are as follows:

1. marked organisms do not lose their marks prior to recapture period.
2. marked individuals are not overlooked in the recapture sample
3. marked and unmarked individuals have equal likelihood of being captured
4. there is no mortality during the sampling period
5. after release, marked individuals and unmarked individuals become randomly mixed.
6. there is no emigration or immigration.

To test to see if the data meets the assumptions of the Schnabel estimate we graphed Ri/Ni on the Y-axis and Mi on the X-axis. Due to issues with the last four days worth of trapping, data was graphed as a complete set and then as only the first seven days of trapping (Figure 2). If the data is in a straight line it meets all assumptions of the Schnabel method. Because only part of the data met assumptions, population estimates were calculated separately for the data that met assumptions and the entire data set.

The 95% confidence intervals were calculated using the Poisson distribution as the number of recaptures was small in W1. Therefore, the confidence intervals were calculated using ∑Ri as the Poisson variable (Ricker, 1975). The 95% confidence intervals were calculated using the Poisson variable as the denominator in the Schnabel equation.

To test the difference in capture rates between W1 and W2 the capture rates were standardized to trap hours and compared using a two sample t-test. Trapping success per subbasin in each wetland was compared using ANOVA and Tukey-Kramer procedures. The growth equation was calculated for the combined wetlands as limited samples were collected from W1. Body size (length/weight) was compared between the two wetlands using a paired t-test. Population estimates and 95% Cl were recalculated from studies during the water fluctuation event in 2003 (Smith and Mitsch, 2004) using the Schnabel method.

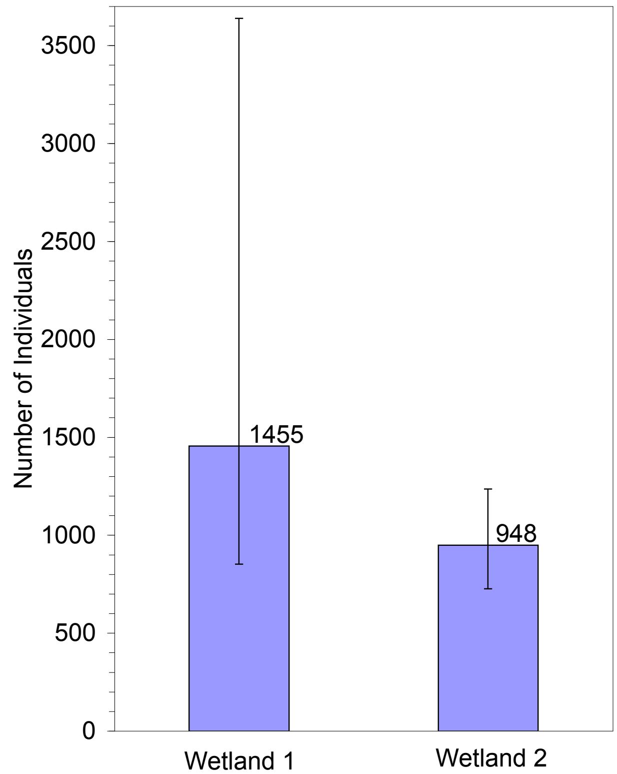

Figure 3. Population estimate for two wetlands from October 8–19, 2005, with bars for the 95% Cl using the Poisson distribution. The number on each bar indicates value.

Results

Out of the six fish species captured green sunfish made up the majority of the fish captured during the 11 days of trapping (Table 1). No other species had enough individuals captured to calculate a population estimate. More green sunfish were captured in W2 than W1, but the population in W1 was estimated to be larger than the population in W2 (Figure 3). There was significantly more fish captured per trap hour in W2 than W1 ($p=0.013$, $t = -2.73$, Figure 4). Outflow and middle subbasins had significantly more fish captured per day in W1 and W2 than the inflow basins (W1, $p = 0.01$, $f = 5.35$ and W2, $p = 0.001$, $f = 12.92$). Populations of fish were higher in 2005 when water levels were constant in the wetlands than when they fluctuated in 2003 (Table 2). A total of eight tadpoles, which were not identified, and two adult bullfrogs were captured in W2.

Fish growth in the two wetlands was not significantly different ($p = 0.938$, $t = 0.08$) so data were combined and a growth equation was created for green sunfish populations in the two wetlands (Figure 5). The two species of bass, largemouth (*Micropterus salmoides* Lacepede) and smallmouth (*Micropterus dolomieui* Lacepede) were aged and found to be at two years of age.

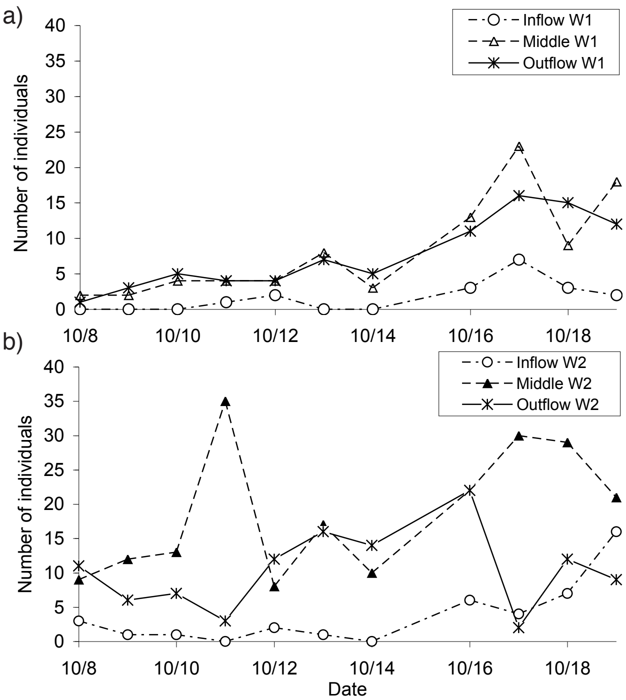

Figure 4. Total number of fish caught per day for (a) Wetland 1 (W1) and (b) Wetland 2 (W2).

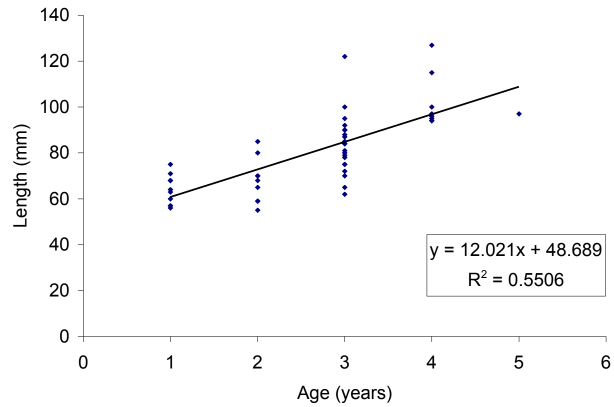

Figure 5. Growth of all green sunfish captured in the two created wetlands.

Discussion

The two created wetlands have had changes in fish species captured over the years, but green sunfish are consistently captured in both wetlands. Green sunfish are a hardy species and are able to survive in environmental extremes such as those found in freshwater marshes. As a predatory fish they are capable of taking advantage of the diversity of insect larvae and other small animals in the highly productive freshwater marsh ecosystem. Green sunfish predation on other young fish (Lohr and Fausch, 1996) coupled with the low water levels and environmental extremes found in these wetlands are likely factors keeping larger fish populations low or absent (with the exception of common carp *Cyprinus carpio* L.). During 2004 common carp were the dominant fish species but the populations were drastically reduced after the wetlands were partially drained in the fall of 2004. Green sunfish quickly became the dominant fish species present after the wetlands were refilled, likely due to their ability to reproduce early and live in extreme environmental conditions (Fink and Mitsch, 2005). The inhospitable environment found in freshwater marshes inhibits many fish from establishing populations. Since few other species are capable of surviving year around under the harsh freshwater marsh conditions the green sunfish population has little competition for food and few aquatic predators. During years of water level fluctuation the population decline of green sunfish could be attributed to the smaller pools during draw-downs, which allowed piscivorous birds easy access to the fish. Also, in low water conditions green sunfish likely eat each other and compete for reduced food resources (Wang et al., 2000). An increase in the carp populations in 2004 may have also negatively affected the green sunfish by competing for food and hiding spots, and by increasing turbidity in the water column reducing the ability of green sunfish to find food and reproduce (Fink and Mitsch, 2005).

The size of the openings in the traps may have limited larger fish from being sampled (Blaustein, 1989). We made larger entrance holes in two traps per wetland to attempt sampling larger fish, but the limited number of fish captured in these traps did not allow us to detect differences between the sizes of fish caught in the two trap sizes. The traps with large entrances may have been more efficient had they been

Table 2. Population estimates in two created wetlands from two years with different water control regimes.

Year	Wetland	Water level status	Population estimate	Upper 95% Confidence Interval	Lower 95% Confidence Interval
2003*	1	fluctuating	352	681	201
2003*	2	fluctuating	356	725	198
2005	1	constant	1455	3638	851
2005	2	constant	948	1236	726

* reanalyzed from Smith and Mitsch, 2003

placed near traps with higher trap success. The traps with large entrances may have also let many of the smaller fish easily escape so it is important to use the small entrance traps in addition to the large entrance traps when sampling small fish.

The growth of fish in these wetlands is likely stunted due to the availability of smaller food items such as invertebrates, as well as the harsh environmental conditions. The maximum length of green sunfish in optimal conditions is 200–250 mm, but the largest fish caught during this study was 127 mm (Robinson and Buchanan, 1988). This limited size could be due to reduced growth as the result of environmental conditions in wetlands or a trap size bias. The largest fish that was caught in a small-holed trap was a 122 mm bluegill. It is likely that these are the largest fish in the wetlands because the largest fish in both the small and large traps were of comparable size. We believe that this is a reasonable assumption because no larger fish were seen while checking traps. During and after flooding years there were larger fish, primarily Common Carp, which made it into the wetlands and were present until removal. Both largemouth and smallmouth bass species were present, but were extremely small for the estimated age of two years for both individuals. It is likely that the harsh environmental conditions caused the growth of bass to be drastically reduced allowing them to exist by remaining at smaller sizes. Survival is reduced for larger individuals in the shallow wetlands because of low water and oxygen levels, and the rapidly fluctuating temperatures (Robinson and Buchanan, 1988). After a flooding event other large species/individuals may be present, but likely disappear quickly.

Dissolved oxygen was not likely a limiting factor for fish in the two created wetlands during this study, as fewer fish were captured in the inflow than in the middle or outflow basins. Other environmental factors may have been important for the location of fish in the wetlands. Temperature difference between the inflow and outflow basins ranged between -0.3^{o}C and 0.9^{o}C (Mitsch and Zhang, 2002). During the fall, when temperatures are typically moderate, the variation in temperatures in the individual basins is not likely the cause of the difference between the numbers of individuals captured in each sub basin. There were no obvious environmental factors to cause the spatial variation in number of individuals captured. Trap location may have been a factor contributing to the lower number of individuals caught in the inflow, as two of the four traps in both W1 and W2 were not completely submerged and were surrounded by vegetation. Vegetation surrounding traps did not likely reduce the number of individuals captured, because smaller fish use vegetation for cover (Blaustein, 1989). Depth was likely the leading cause for the low number of individuals captured in the inflow sub basins as Blaustein (1989) found that there were significantly fewer green sunfish (but not mosquito fish) in traps that were at 8 cm, compared to traps at 24 cm deep. In future studies, traps should be standardized at a certain depth to make trapping effort equal in each sub basin.

Conclusions

The population in W1 was estimated to be 50% larger than W2 although there were no apparent reasons for this difference. Fish species diversity was similar between the two wetlands; more than 98% of all fish captured are green sunfish with the other 2% consisting of three other species captured in each wetland. Significantly more fish were captured in the outflow and middle sub basins than in the inflow basin. Trap depth likely played a role in the number of individuals captured in each sub basin and in the future trap depth should be standardized between all sub basins to get a fair comparison. Comparison of amphibians between the two wetlands could be an interesting addition to this study if weather conditions are warm enough to allow amphibian species to be active.

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